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Type:	Information
Category:	General
Subject:	improved survey analysis

A number of corrections and enhancements have been made in the analysis of the survey data, resulting in (arguably) agreement at the level of 3.5 cm or better between the calculation and the survey. This is quite close to our physics goal! The changes that were made included a correction to the pulley encoder recalibration, the addition of the cable mass to the potential energy function, and the retuning of some of the geometry parameters.

First, Herb pointed out a combination of presentation and arithmetic errors in the new pulley encoder calibration coefficients. The full data set follows:

```
Cable 1:
-------------------------------------------------------
indicated -- down -- up -- average [cm]
-------------------------------------------------------
2 m -- 6' 6 1/4" -- 6' 6" -- 198.44
4 m -- 13' 1/8" -- 13' 1/8" -- 396.56
6 m -- 19' 6 3/8" -- 19' 6 1/4" -- 595.15
8 m -- 26' 1/4" -- 26' 1/8" -- 792.96
9 m -- 29' 3 1/4" -- 29' 3 1/4" -- 892.18

Cable 2:
-------------------------------------------------------
indicated -- down -- up -- average [cm]
-------------------------------------------------------
2 m -- 6' 6 1/8" -- 6' 6 1/8" -- 198.44
4 m -- 13' -- 12' 11 7/8" -- 396.08
6 m -- 19' 5 7/8" -- 19 5 3/4" -- 593.88
8 m -- 25' 11 5/8" -- 25 11 1/2" -- 791.37
9 m -- 29' 2 1/2" -- 29' 2 1/2" -- 890.27
```

From this, the coefficients 0.99149 (cable 1) and 0.98940 (cable 2) follow. The revised cable lengths are then

```
--------------------------------
Position -- L1 -- L2
--------------------------------
Vertical -- 592.23 -- 1002.47
Horizontal -- 1029.98 -- 985.85
"+30" -- 583.82 -- 745.33
"+60" -- 583.82 -- 916.82
"-30" -- 583.82 -- 368.32
"-60" -- 583.99 -- 246.06
```

```
------------------------------
```

Next, the control program was modified to include the effect of the weight of the cables on the center of gravity of the system. Indeed, this modification seems to move the reconstructed source position by several cm in the +/- 60 degree configurations, so this is an important effect to include.

The lengths of various components of the system were then tuned to match the survey data in the vertical position:
- Fixed length to pivot block: from 469.1 cm to 467.9 cm
- Distance from cable 1 to cable 2 attachment point: from 401.2 cm to 401.0 cm
- Distance from cable 2 attachment point to source: from 123.36 cm to 124.87 cm

The assumed CG was tuned from 248.76 cm to 252.50 cm to match the survey in the horizontal.

With these modifications, the calculated and surveyed coordinates are:

```
Pivot block:
-------------------------------------------------
Position -- Calculated -- Surveyed
-------------------------------------------------
Vertical -- (0, 475.68 ) -- (0, 836.50)
Horizontal -- (0, 37.92) -- (0, 400.82)
"+30" -- (0, 484.08 ) -- (0.20, 846.90)
"+60" -- (0, 484.08 ) -- (0.02, 847.00)
"-30" -- (0, 484.08 ) -- (0.70, 847.29)
"-60" -- (0, 483.91) -- (1.04, 847.07)

Cable attachment 1:
-------------------------------------------------
Position -- Calculated -- Surveyed
-------------------------------------------------
Vertical -- (-1.50, 7.78 ) -- (-2.45, 368.65)
Horizontal -- (-247.35, -360.18 ) -- (-246.02, 0.00)
"+30" -- (-215.73, 68.11) -- (-214.62, 429.58 )
"+60" -- (-125.47, 32.91) -- (-123.44, 393.03)
"-30" -- (-212.79, 66.61) -- (-212.23, 427.26)
"-60" -- (-125.35, 32.70) -- (-128.89, 396.84)

Cable attachment 2:
-------------------------------------------------
Position -- Calculated -- Surveyed
-------------------------------------------------
Vertical -- (1.50, -393.22) -- (-3.71, -32.39)
Horizontal -- (153.63, -357.59) -- (155.16, 0.00)
"+30" -- (131.95, -131.66) -- (132.23, 225.87)
"+60" -- (76.92, -313.26) -- (76.20, 46.05)
"-30" -- (133.43, 268.91) -- (136.75, 627.68 )
"-60" -- (77.59, 378.55) -- (83.55, 737.77)

Source:
-------------------------------------------------
Position -- Calculated -- Surveyed
-------------------------------------------------
Vertical -- (-1.50, -518.09) -- (-3.07, -157.26)
Horizontal -- (278.52, -360.23) -- (279.49, 1.77)
```

```
"+30" -- (238.51, -196.85) -- (240.04, 163.92)
"+60" -- (136.98, -422.78 ) -- (139.80, -61.68 )
"-30" -- (242.98, 328.93) -- (245.19, 690.65)
"-60" -- (143.75, 484.50) -- (148.40, 843.38 )
```

Now, relative to the pivot block:

```
Cable attachment 1:
-----------------------------------------------------
Calculated -- Surveyed -- Discrepancy
-----------------------------------------------------
(-1.50 -467.90) -- (-2.45 -467.85) -- 0.95
(-247.35 -398.10) -- (-246.02 -400.82) -- 3.03
(-215.73 -415.97) -- (-214.82 -417.32) -- 1.63
(-125.47 -451.17) -- (-123.46 -453.97) -- 3.45
(-212.79 -417.47) -- (-212.93 -420.03) -- 2.56
(-125.35 -451.21) -- (-129.93 -450.23) -- 4.68

Cable attachment 2:
-----------------------------------------------------
Calculated -- Surveyed -- Discrepancy
-----------------------------------------------------
(1.50 -868.90) -- (-3.71 -868.89) -- 5.21
(153.63 -395.51) -- (155.16 -400.82) -- 5.53
(131.95 -615.74) -- (132.03 -621.03) -- 5.29
(76.92 -797.34) -- (76.18 -800.95) -- 3.69
(133.43 -215.17) -- (136.05 -219.61) -- 5.16
(77.59 -105.36) -- (82.51 -109.30) -- 6.30

Source:
-----------------------------------------------------
Calculated -- Surveyed -- Discrepancy
-----------------------------------------------------
(-1.50 -993.77) -- (-3.07 -993.76) -- 1.57
(278.52 -398.15) -- (279.49 -399.05) -- 1.32
(238.51 -680.93) -- (239.84 -682.98 ) -- 2.44
(136.98 -906.86) -- (139.78 -908.68 ) -- 3.34
(242.98 -155.15) -- (244.49 -156.64) -- 2.12
(143.75 0.59) -- (147.36 -3.69) -- 5.60
```

The agreement for cable attachment 2 appears somewhat worse than for the other two fiducial points. I believe that the survey refers to a position on the pole centerline, while the value from the control program is the center of the cable clamp, which is offset from the centerline by 2.6 cm.

Similarly, the agreement for the "+60" configuration seems worse than the others. At this point, Andrew and I noted that the cable clamp was not parallel to the cable, but was bent to a sharper angle. This effect may account for several cm of discrepancy; we do not plan to use pole angles this far beyond the horizon, partly for this reason.

If we agree to look only at the two ends of the pole (and not cable attachment 2) and to discard the +60 point, then we find that all positions agree within 3.5 cm.